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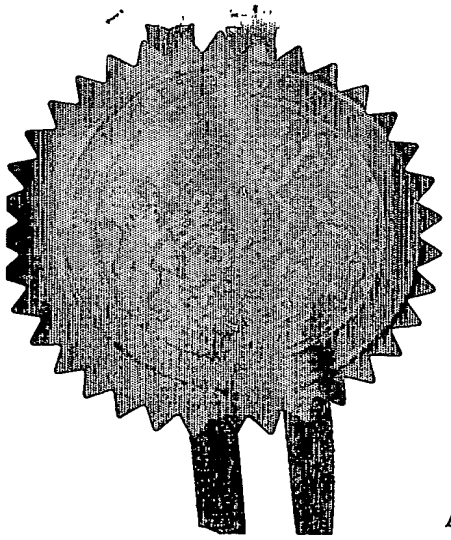

Signed K Behen

Dated 15 September 2003

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The Patent Office

Cardiff Road
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NP9 1RH

1. Your reference NRJ/P34102GB

2. Patent application number
(The Patent Office will fill in this part) 0219708.5 | 23 AUG 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Mayflower Engines Limited,
Mayflower House,
London Road, Loudwater,
High Wycombe, Buckinghamshire HP10 9RF,
England.

8451601001

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

England.

4. Title of the invention

INTERNAL COMBUSTION ENGINES

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Kilburn & Strode
20 Red Lion Street
London
WC1R 4PJ

Patents ADP number *(if you know it)* 125001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

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Continuation sheets of this form	
Description	8
Claim *(s)*	
Abstract	
Drawing *(s)*	1 + 6 sht

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Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature K J Wade Date 23 August 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr. N.R. Jennings
Tel: 020 7539 4200

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INTERNAL COMBUSTION ENGINES

The present invention relates to internal combustion engines of the type in which the compression ratio and the swept volume may be altered during operation of the engine. More specifically, the invention relates to internal combustion engines including one or more pistons, each of which is mounted to reciprocate in a respective cylinder and is pivotally connected to a connecting rod which is connected to a respective crank on a crankshaft, the connecting rod being pivotally connected to one end of an elongate link member which is pivotably connected to the associated crank at a point intermediate its ends and whose other end constitutes a rod which is restrained by a mounting such that it may pivot about a pivotal axis parallel to the axis of the crankshaft, the mounting including a first movable mounting member and a second movable mounting member, the first movable mounting member being connected to the rod by a connection which permits only relative sliding movement in the direction of the length of the rod and the first movable mounting member being connected to the second movable mounting member to be pivotable with respect thereto about the said pivotal axis, a single actuating means being provided which cooperates with the second movable mounting member and is arranged to move it.

Such an engine is disclosed in EP-B-0898644. In the engine disclosed in this patent, the first mounting member comprises a sleeve or the like which slidably retains the rod of the link member and is pivotally connected to the second mounting member which is selectively movable by an actuator in a direction parallel to the axis of the associated cylinder. Movement of the first mounting

member in this direction results primarily in a change in the top dead centre position of the piston and thus in the compression ratio, though also in a small change in the bottom dead centre position of the piston and thus in the stroke of the piston.

It is, however, often desirable to be able to make a substantial change to the stroke of the piston and thus to the swept volume of the engine and to this end EP-B-1012459 discloses a modified engine which includes two actuators. The first actuator is arranged to move the first mounting member parallel to the cylinder axis, and thus changes the compression ratio of the engine, and is carried by the second actuator, which is arranged to move the first actuator and thus the first mounting member perpendicular to the cylinder axis and thus changes the stroke of the piston and thus the swept volume of the engine. The engine of EP-B-1012459 is thus superior to that of EP-B-0898644 because it enables the compression ratio and the swept volume of the engine to be changed at will independently of one another.

However, the inclusion of a second actuator in the engine of EP-B-1012459 adds not inconsiderably to its structural complexity and cost and also to the complexity of the control system that is required. Although the engine may be operated with any desired combination of values of compression ratio and swept volume within the ranges that may be obtained, it is now appreciated that this is in fact not necessary in all cases. Thus at relatively low speed and/or load a relatively small swept volume and a relatively high compression ratio are desirable whilst at relatively high speed and/or load a relatively large swept volume and a relatively low compression are desirable. Although the actuators are able to position the mounting so that a large swept volume is provided in

combination with a high compression ratio and also a small swept volume in combination with a low compression ratio, these operating configurations may in practice rarely be required.

A further problem in connection with the engines disclosed in the prior patents referred to above is that it is necessary for a solid fixed structure to be provided beside the engine roughly at the level of the crankshaft. In practice, in a some vehicle engine compartments, there is no such structure and space constraints may render the provision of such a fixed structure difficult.

It is, therefore, the object of the invention to provide an engine of the type referred to above which has the advantage of being able to adjust both the compression ratio and the swept volume but does not have the additional complexity and expense of a second actuator and does not need a fixed structure laterally of the crankshaft to which the actuator is to be connected.

According to the present invention, the second movable mounting member is an elongate lever which is connected to a fixed structure to pivot with respect thereto about an axis substantially parallel to the axis of the crankshaft.

Thus in the engine in accordance with the invention, the mounting for the elongate bar comprises a sleeve or the like which slidably retains the bar within it and is pivotally connected to one end of an elongate lever, the other end of which is pivotally connected to a fixed structure. The actuator cooperates with the elongate lever and can move it only in rotation about its pivotal axis. This necessarily means that the first mounting member is moved not linearly but over an arcuate path. Movement along this arcuate path may be resolved into

movement perpendicular to the axis of the cylinder and movement parallel to the axis of the cylinder and thus operation of a single actuator will result in both the compression ratio and the swept volume of the engine changing. The precise ratio of movement perpendicular and parallel to the cylinder axis between the end points of the arcuate path may be varied in accordance with requirements by altering the length of the elongate lever and the position of its pivotal mounting.

As mentioned above, it has been appreciated that it may not be necessary to provide a full range of combinations of compression ratio and swept volume and the invention is based on the recognition that if one plots the combinations of compression ratio and swept volume which are actually useful in practice on a graph of compression ratio against swept volume, the various points lie for many engines on a generally arcuate line. By appropriately dimensioning the elongate lever and positioning its pivot point, the first mounting member can be caused to move along an arcuate path which corresponds in qualitative terms to the arcuate line referred to on the graph above. This means that by providing a pivotally mounted elongate lever, it is possible for the mounting to be adjusted to obtain substantially all the combinations of compression ratio and swept volume that are in practice normally required using only a single actuator.

The actuator, which is preferably a linear actuator, may act directly on the elongate lever. However, in a preferred embodiment the elongate lever is non-rotatably mounted on an actuator shaft which is rotatably mounted in fixed mountings, i.e. bearings, and the actuator acts on the shaft to rotate it. In this case, the actuator may be a rotary actuator which acts directly on the actuator shaft but it is preferred that the engine includes an actuator lever which is also

non-rotatably connected to the actuator shaft and that the actuator acts on the actuator lever, in which case the actuator may again be of linear type. Thus the actuator shaft may be of non-circular section, e.g. hexagonal, splined or the like, and the elongate lever and the actuator lever, if provided, will then have a hole in one end whose shape corresponds to that of the actuator shaft. Movement of the free end of the actuator lever will then result in rotation of the actuator shaft within its fixed mountings which will in turn result in pivotal movement of the elongate lever and thus movement of the first movable mounting member along an arcuate path.

It is likely that the actuator will be of positive type, that is to say of the type which is powered, e.g. electrically or hydraulically and actively causes the elongate lever to move pivotally about its mounting axis. However, this may not be essential and in a further embodiment the actuator is of negative type, that is to say it does not actively cause the elongate lever to move but instead merely permits it to move. In this embodiment, the actuator is therefore more in the form of a selectively releasable lock. Thus tests have shown that the elongate rod exerts substantial fluctuating moments on the mounting and these moments tend to cause pivotal movement of the elongate lever in one direction and then in the other direction alternately. It is therefore possible to make use of these moments or torques by locking the mounting in position and, at the time at which it is desired to move the elongate lever in a specific direction, sensing when the torque is tending to cause the elongate lever to move in that direction and then releasing the releasable lock to permit the desired movement to occur, whereafter the releasable lock is reapplied. In practice, it may not be possible for all of the desired movement of the elongate lever to occur in a single continuous movement because the torque applied to it fluctuates and

reverses very rapidly and it may therefore be necessary for the releasable lock to be released on each of a number of successive occasions when the torque acting on it is acting in the correct direction and reapplying the lock at times between those occasions, whereby the elongate lever will move incrementally until it has reached the desired position.

Actuation of the positive actuator or release of the selectively releasable lock will of course be controlled by a central control system, e.g. incorporated in the engine management system, which is now conventionally provided on automotive engines, in response to signals produced by a number of sensors indicative of, amongst other things, engine load, engine speed, position of the crankshaft and the like.

Further features and details of the invention will be apparent from the following description of one specific embodiment which is given by way of example only with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a schematic view showing only a single cylinder of a multi-cylinder four-stroke engine in accordance with the invention with the mounting shown in the position in which the engine has a low compression ratio and a high capacity or swept volume; and

Figure 2 is a similar view but with the mounting in the position in which the engine has a high compression ratio and a low capacity or swept volume.

In this embodiment, the engine has four cylinders, though it may have more or less than this or even only a single cylinder, but only a single cylinder 2 is

shown. Reciprocably mounted in the cylinder is a piston 4. The piston is pivotally connected about an axis 5 in the usual manner to a connecting rod 6. Extending below the or each cylinder 2 is a crankshaft 7, which carries a respective crank or crank throw for each piston. The connecting rod 6 is not directly connected to the associated crank but instead pivotally connected about an axis 12 to one end 11 of a respective elongate link 14. The link is also pivotally connected at a point intermediate its ends to the associated crank. The other end 18 of the link 14, which is in the form of a bar, is longitudinally slidably received in a mounting. The bar 18 may be of circular section, in which event it may be hollow, or it may be cut away for weight-saving purposes, in which case it may be generally of I cross-section or cruciform cross-section, with webs defining an outer surface of substantially circular shape to facilitate longitudinal sliding and lateral force transfer.

The mounting includes a first movable mounting member 20, which is constituted by a sleeve defining a hole or passage through which the bar 18 passes and is slidably retained therein. The sleeve 20 is accommodated in the space between and pivotally connected to the two limbs 22 of a respective bifurcated mounting lever 24. The sleeve 20 may thus pivot or rotate with respect to the lever 24 about an axis which is parallel to the axis of the crankshaft. At its other end, the lever 24 has a hole of non-circular shape in which a complementarily shaped actuator shaft 26 is non-rotatably received. The actuator shaft 26 is retained at its two ends by stationary bearings, e.g. mounted on the side of the cylinder block, and thus cannot move linearly but is mounted to rotate about its own axis in the bearings. Also connected to the actuator shaft 26 is an actuator lever 28, which is again non-rotatable with respect to the shaft 26. Connected to the free end of the actuator lever 28 is a

hydraulic linear actuator (not shown). Extension or retraction of the actuator will result in rotation of the shaft 26 about its axis and thus in rotation also of the mounting lever 24 about the axis of the shaft 26. The sleeve 20 is thus caused to move over an arcuate path.

In use, the engine operates in substantially the same manner as that disclosed in EP-B-1012459, to which reference should be made. During steady state operation of the engine, the bar 18 reciprocates linearly within the sleeve 20 and the sleeve 20 reciprocates rotarily about its pivotal connection with the lever 24. If the engine is operating at high speed and/or under high load, the mounting is held in the position shown in Figure 1 in which the compression ratio is relatively low and the swept volume of the engine is high. If, however, the speed and/or load should drop, this is sensed by various sensors and the engine management system then issues a signal to the actuator to move the mounting into the position shown in Figure 2 in which the compression ratio is relatively high and the capacity of the engine relatively low. The engine management system can be programmed to move the mounting progressively between its two end positions or alternatively it may be programmed to switch the mounting between the two end positions or to switch it incrementally between any predetermined number of set positions.

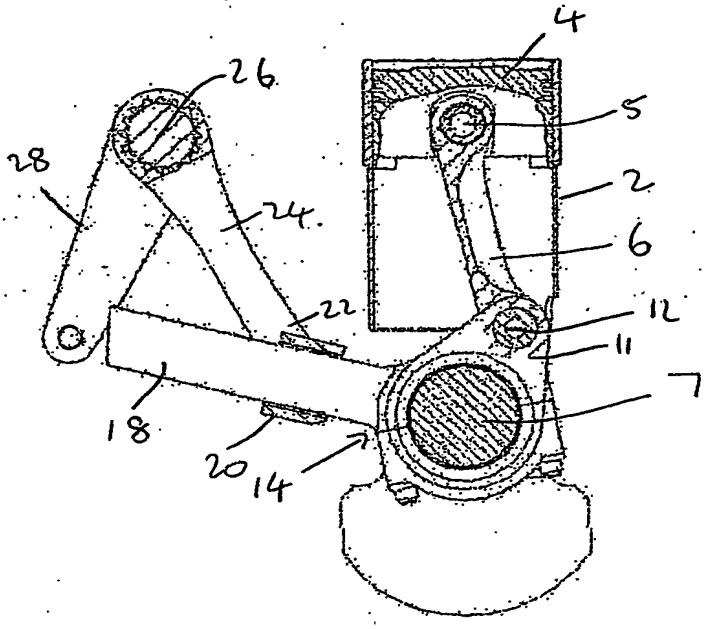

Fig 1

PIVOT SHOWN IN LOW COMPRESSION HIGH CAPACITY POSITION

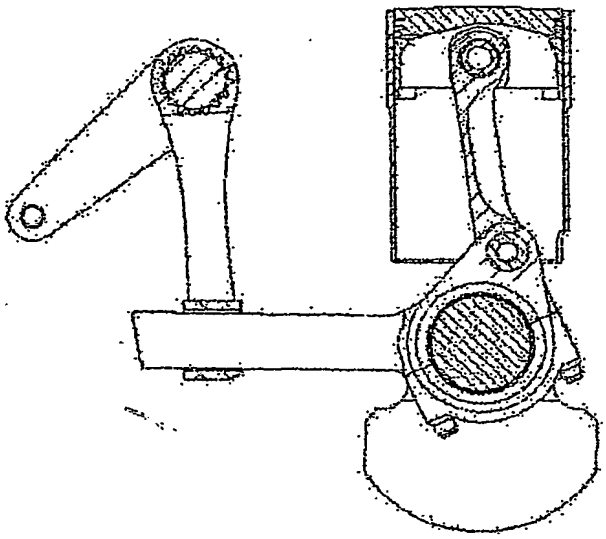

Fig 2

PIVOT SHOWN IN HIGH COMPRESSION LOW CAPACITY POSITION

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